



**Relationships between the Symptomatology and
Neuropsychology of Schizophrenia: Three, Five,
Eleven, or a Greater Number of Valid
Syndromes?**

Raimondo Bruno

BSc (Hons) MAPS

Submitted in fulfilment of the requirements for the Degree of
Doctor of Philosophy (Clinical Psychology)

University of Tasmania

September 2005

This thesis contains no material which has been accepted for a degree or diploma by the University of any other institution, except by way of background information and duly acknowledged in the thesis; and to the best of my knowledge and belief no material previously published or written by another person except where due acknowledgement is made in the text of the thesis.

This thesis may be made available for loan and limited copying in accordance with the *Copyright Act 1968*.

A handwritten signature in purple ink, appearing to read 'R. Bruno', with a horizontal line underneath.

Raimondo Bruno
September 2005

Abstract

The marked heterogeneity between individuals diagnosed as experiencing schizophrenia has troubled nosologists since the very coining of the term. Catalysed by Crow's (1980) hypothesis of independent 'positive' and 'negative' syndromes, which led to substantial breakthroughs in our comprehension of schizophrenia, the last two decades have seen a resurgence of interest in the characterisation of symptom dimensions to resolve the issue of heterogeneity. A three-dimensional model, comprising 'psychotic', 'negative' and 'disorganised' syndromes has received considerable research attention and has been proposed for inclusion in the Diagnostic and Statistical Manual of Mental Disorders. Similarly, a five-dimensional model, adding syndromes of 'affective disturbance' and 'excitement', has also attracted an increasing profile of literature. Mounting evidence suggests, however, that these models do not adequately reflect the diversity of symptoms seen among those with a diagnosis of schizophrenia, and that they may emerge as an artefact of lossy factor-analytic techniques applied to measurement models biased or inadequate in their coverage of symptoms. To overcome such limitations, in the present study one hundred in- and out- patients diagnosed with schizophrenia were assessed for symptoms using a comprehensive series of assessment scales. Additionally, participants completed a battery of neuropsychological tests tapping five aspects of attention, and smooth pursuit eye tracking was also recorded. Using cluster analyses to examine correlations between symptoms, eleven groups of symptoms were identified: 'hostility', 'conceptual disorganisation', 'bizarre behaviour', 'grandiosity', 'auditory hallucinations', 'loss of boundary delusions', 'paranoia', 'anxious intropunitiveness', 'cognitive dysfunction', 'negative signs' and 'social dysfunctions'. All groupings were internally consistent, largely independent of others, and supported by other symptom models

proposed in the literature. Several of the symptom groupings were validated by demonstration of independent relationships with neuropsychological variables or aspects of eye movements, and the more complex symptom model was equivalent or superior in the prediction of neuropsychological performance than the three- and five- factor symptom models.

Implicit in dimensional approaches to conceptualising schizophrenia is the notion that the identified groupings may reflect the functioning of distinct brain systems. This thesis has demonstrated that the ‘syndromes’ defined by the three- and five- dimensional models of schizophrenia are actually heterogeneous groupings of poorly correlated symptoms. This, in turn, obscures the relationships between symptoms and underlying pathology. Dimensional approaches to psychopathology hold great promise for unravelling the nature of psychosis. However, the existing facile descriptions may actively constrain the potential for research progress. The rigorously developed description of symptomatology presented here represents a compact and useful representation of the spectrum of symptoms experienced in schizophrenia, and has demonstrated an advantage over existing conceptions that demands implementation and vigorous research attention.

Acknowledgements

First and foremost, to Jackie Hallam, for making *everything* worthwhile.

Dr Walter Slaghuis, for your ongoing support, guidance and encouragement, and for weathering food poisoning in the name of this work.

Dr Geoff Stuart for statistical advice, and (unwittingly) inspiring the ideas behind this thesis at the 1998 Australasian Schizophrenia Conference.

Tom O'Brian, Andre Declerk, A/Prof Saxby Pridmore, Audrey Lowrie, and Barb Smith for substantial support with encouragement and recruitment of participants; and to the staff of the Royal Hobart Hospital Department of Psychological Medicine, Richmond Fellowship, Tolosa Street Rehabilitation Service, Peacock Centre, Campbell House, Gavitt House, Bellereve Centre and Derwent Valley Centre for providing time and space for conducting interviews with participants.

Importantly also to the one hundred participants that very kindly volunteered to take part in this study.

Table of Contents

Abstract	iii
Acknowledgements.....	v
Table of Contents	vi
List of Tables	x
List of Figures.....	xvi
Introduction: Describing the Unknown: Psychopathology, symptomatology and nosology of schizophrenia	1
Schizophrenia: The origins of the concept and its cardinal symptoms	2
Dimensional Approaches to Describing Schizophrenia – An Overview.....	30
Positive and Negative: The misunderstood catalyst for interest in dimensional models of schizophrenia	30
Scales for Assessing Psychosis I: Andreasen’s SANS and SAPS	38
Scales for Assessing Psychosis II: The BPRS and the PANSS	52
Revising the Model: Two factors become three.....	61
Further Down the Rabbit-Hole: Different Scales, Different Models	78
Everything you wanted to know about factor analysis but were afraid to ask: The limitations of exploratory factor analysis and default program settings	99
They don’t make ‘em like they used to: Structural models of the symptomatology of psychosis in the era before Crow	122
Aims of this thesis	142
Study One: Identification of a Symptom Model.....	142
Method.....	144
Participants.....	144
Materials	147
Procedure	148
Data Analysis	149
Results	151
Item Selection.....	151
Cluster Analysis	154
Sorted Correlation Matrix.....	160
Disorganisation and Mania	165
Hostility.....	165
Inappropriate Affect	171
Bizarre Behaviour.....	172
Conceptual Disorganisation.....	173
Excitement.....	175
Grandiosity	177
Reality Distortion	178
Loss of Boundary Delusions.....	179
Somatisation	184
Auditory and Visual Hallucinations	186
Affective Disturbance	189
Paranoia	189
Affective Symptoms (Anxiety, Depression, Mood-Congruent Delusions)	193
Negative/Cognitive Symptoms.....	198
Cognitive Dysfunction.....	201
Negative Symptoms	202
Blunting and Alogia.....	204
Social Dysfunctions and Anergia	207

Working Symptom Model	210
Confirmatory Factor Analysis	215
Discussion.....	220
Methodological Challenges.....	232
Instruments and Item Set.....	232
Symptom rating methodology	236
Statistical issues.....	238
Participant Characteristics	243
i. Potential confounds.....	243
ii. Symptom expression.....	247
Cross-sectional sampling and issues of longitudinal stability.....	258
Interpretation.....	264
Study Two: Validation of Symptomatological Models of “Schizophrenia”: I.	
Relationships with Neuropsychological Components of Attention.....	277
Sustained Performance/Sustain.....	290
Active Switching /Shift.....	297
Memory Capacity / Encode	310
Processing Speed / Focus-Execute.....	321
Response Intention.....	329
Response Initiation and Inhibition.....	337
Summary.....	343
Method.....	345
Participants.....	345
Materials	347
Stroop Task (Victoria Version)	347
Trail Making Test	348
Simple Reaction Time.....	348
Finger Tapping Task.....	349
Symbol Search (WAIS-III).....	349
Digit-Symbol and Digit-Symbol Copy (WAIS-III)	350
Arithmetic (WAIS-III).....	350
Letter-Number Sequencing (WAIS-III).....	351
Digit Span (WAIS-III)	351
Spatial Span (WMS-III)	351
Continuous Performance Task – Identical Pairs Version	352
Modified Wisconsin Card Sort (MWCST).....	353
Controlled Oral Word Association Task (COWAT)	354
Antisaccade Task	355
Procedure	356
Data Analysis	357
Results.....	360
General Performance on Neuropsychological Tests	360
Determining the Structure of Measures of Attentional Performance	364
Constructing Comparison Symptom Models.....	374
Symptom Dimensions as Predictors of Domains of Attention	389
1. Speed.....	391
2. Sustain	406
3. Span	413
4. Focus	420
5. Flexibility.....	422
Discussion:	431

What are the implications of these results for Cohen's (1993) neuropsychological model of attention within those diagnosed with schizophrenia?	431
Is there evidence for the validity of the eleven-factor model of symptoms?	435
1. Were symptom measures useful predictors of performance?	435
2. Did the eleven-factor model of symptoms show any advantages over more parsimonious symptom models?	442
3. Is there evidence that the symptom groupings in the three- and five- factor models harbour heterogeneous sub-groups?	446
Reconciling the findings: A conceptual framework	452
Methodological Issues	454
Complexities of the Neuropsychological Tasks.....	454
Symptom Groupings.....	458
Participant Characteristics	459
Analysis Logic	461
Item Set Artefacts.....	462
Symptoms, Neurocognition and Outcome: A framework for reconciling these findings	465
Schizophrenia as a Neurocognitive Disorder?	465
Neurocognition and Outcome: A framework.....	469
Summary:	475
Study Three: Validation of Symptomatological Models of 'Schizophrenia': II.	
Relationships with Pursuit Eye Tracking Performance.....	478
History of eye movement research in the context of schizophrenia.....	478
Oculomotor systems involved in eye tracking.....	484
The nature of the eye tracking deficit in schizophrenia	487
Neurology of pursuit	496
Other influences on eye tracking performance	499
Medication Effects	499
Medication-induced movement disorders	502
Smoking	503
Temporal Stability and Age Effects.....	504
Attention and General Neurocognitive Function	507
Open questions in regard to eye tracking deficits and schizophrenia.....	509
Method.....	523
Participants	523
Apparatus.....	525
Method.....	526
Data Analysis.....	527
Results	532
General Smooth Pursuit Eye Movement Performance	532
Symptom Dimensions as Predictors of Eye Movement Performance	542
1. Single-mode Pursuit Gain	544
2. Positive (forward-direction) Saccades	553
Qualitatively Defined Eye Tracking Disordered Subgroup Analyses	577
Discussion.....	581
Summary of Findings	581
Consistency of group level findings with previous literature	583
Qualitatively-defined eye tracking disorder groups.....	587
Does this study provide evidence for the validity of the eleven-factor model of symptoms?	590
1. Were symptom measures useful predictors of eye tracking performance?	590

Single-mode gain	591
Positive saccade frequency	593
Reversal saccade frequency	597
2. Did the eleven-factor model of symptoms show any advantages over the more parsimonious symptom models?	600
3. Is there evidence that the symptom groupings in the three- and five- factor symptom models harbour heterogeneous sub-groups?.....	604
Methodological limitations	609
Symptom Groupings.....	610
Participant Characteristics	612
Research design.....	614
Eye tracking recording technique.....	615
Saccade identification.....	617
Taxonomy of saccades.....	618
Summary.....	621
Summary: Overview of findings and future directions	626
Study Rationale.....	626
Study One: Phenomenology.....	630
Study Two: Neuropsychology.....	631
Study Three: Psychophysiology	633
Summary of evidence for the validity and independence of symptom groupings .	636
Future directions	640
The rationale for the push toward greater complexity	643
References	647
Appendix 1: Semi-structured Interview Schedule	750

List of Tables

Table 1: Comparison of the three most common diagnostic criteria for schizophrenia..	16
Table 2: The Scale for the Assessment of Positive Symptoms (SAPS).....	41
Table 3: The Scale for the Assessment of Negative Symptoms (SANS)	42
Table 4: Confirmatory factor analytic investigation of the subscale structure of the Scale for the Assessment of Negative Symptoms	49
Table 5: Confirmatory factor analytic investigation of the subscale structure of the Scale for the Assessment of Positive Symptoms: Peralta and Cuesta (1998).....	50
Table 6: The Brief Psychiatric Rating Scale (and extension items).....	54
Table 7: The Positive and Negative Symptom Scale (Kay, Opler & Fiszbein, 1986)	57
Table 8: Confirmatory factor analytic investigations of the relationships between global symptom items of the Scale for the Assessment of Negative Symptoms and the Scale for the Assessment of Positive Symptoms (or similar instruments)	70
Table 9: Symptom structures identified in studies examining the relationship between the Scale for the Assessment of Positive Symptoms (SAPS) and the Scale for the Assessment of Negative Symptoms (SANS) at the item level.	75
Table 10: Symptom structures identified in studies examining the relationship between symptoms in the Positive and Negative Syndrome Scale or the Brief Psychiatric Rating Scale at the item level. Part One: Five-factor structures only	83
Table 11: Symptom structures identified in studies examining the relationship between symptoms in the Positive and Negative Syndrome Scale or the Brief Psychiatric Rating Scale at the item level. Part 2: Structures identified other than five-factors .	84
Table 12: Comparison of five-factor structures derived from the 18-item Brief Psychiatric Research Scale and its 30-item extension, the Positive and Negative Syndrome Scale	87
Table 13: Confirmatory factor analytic investigations of the relationships between symptom items of the Positive and Negative Symptom Scale or Brief Psychiatric Rating Scale^.....	93
Table 15: Longitudinal confirmatory factor analytic study of the symptom structure of the Brief Psychiatric Rating Scale	95
Table 16: Symptoms seen in schizophrenia that are also seen in other diagnoses: after Andreasen et al 1992	119
Table 17: Summary of pre-1980 factor analytic studies of psychosis (after Lorr, Klett & McNair, 1963; Lorr, 1986)	127
Table 18: Summary of symptom structure in psychosis using less common symptom rating scales, or combinations of scales	128
Table 19: Summary of studies of the structure of psychosis with broad measurement models and oblique rotation of factors and/or using methods to maximise explained variance	132
Table 20: Descriptive statistics of clinical item ratings on the current sample (n=100).	153
Table 21: Correlations between symptoms within the broad ‘disorganisation’ and ‘mania’ groupings^ identified through cluster analysis.....	168
Table 22: Item-scale reliability statistics for various combinations of items within the broad ‘disorganisation’ and “mania” groupings identified by cluster analysis	169
Table 23: Correlations between symptoms within the broad ‘reality distortion’ grouping^ identified through cluster analysis	180
Table 24: Item-scale reliability statistics for various combinations of items within the broad ‘reality distortion’ grouping identified by cluster analysis	181

Table 25: Correlations between symptoms within the broad ‘affective disturbance’ grouping^ identified through cluster analysis and examination of the sorted symptom correlation matrix	190
Table 26: Item-scale reliability statistics for various combinations of items within the broad ‘affective disturbance’ grouping identified through cluster analysis and examination of the sorted symptom item correlation matrix.....	191
Table 27: Correlations between symptoms within the broad ‘negative’ grouping^ identified through cluster analysis	199
Table 28: Item-scale reliability statistics for various combinations of items within the broad ‘negative’ symptom grouping identified by cluster analysis.....	200
Table 29: Item-scale reliability statistics for the symptom item groupings identified in the current study.....	212
Table 30: Correlations between the symptom item groupings identified in the current data set	218
Table 31: Power calculations for Pearson correlations between items in the current data set – lower diagonal sample size required for Pearson correlation to be $\alpha = 0.05$, $\beta = 0.08$; upper diagonal sample size required for Pearson correlation to be $\alpha = 0.01$, $\beta = 0.08$	219
Table 32: Summary of studies of the structure of psychosis with broad measurement models and oblique rotation of factors and/or using methods to maximise explained variance	227
Table 33: Comparison of symptom base rates across different clinical sample types	255
Table 34: Neuropsychological tests of domains of attention (after Cohen, 1993).....	285
Table 35: Key studies of the structure of neuropsychological measures of attention	289
Table 36: Relationships between performance on tests of the ‘sustained performance’ component of attention (Continuous Performance Task d' sensitivity score) and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia	296
Table 37: Relationships between performance on tests of the ‘active switching/shift’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part I. Wisconsin Card Sorting Test percent perseverative errors.	306
Table 38: Relationships between performance on tests of the ‘active switching/shift’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part II. Wisconsin Card Sorting Test percent perseverative errors (continued)	307
Table 39: Relationships between performance on tests of the ‘active switching/shift’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part III. Wisconsin Card Sorting Test (number of categories completed).....	308
Table 40: Relationships between performance on tests of the ‘active switching/shift’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part IV. Trail-making test interference ratios.....	309
Table 41: Relationships between performance on tests of the ‘memory capacity/encode component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part I. Digit Span – Forward and Backward components	318
Table 42: Relationships between performance on tests of the ‘memory capacity/encode component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part II. Digit Span (total) and Corsi Blocks (total).....	319
Table 43: Relationships between performance on tests of the ‘memory capacity/encode component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part III. Letter-Number Span and Arithmetic.....	320

Table 44: Relationships between performance on tests of the ‘processing speed/focus-execute’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part I. Strong measures of processing speed: Digit Symbol Test and Trail Making Test Part A.....	327
Table 45: Relationships between performance on tests of the ‘processing speed/focus-execute’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part II. Complex measures with heavy loadings on processing speed: Trail Making Test Part B and Cancellation tasks	328
Table 46: Relationships between performance on tests of the ‘response intention’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part I. Phonemic fluency - Controlled Oral Word Association Task	335
Table 47: Relationships between performance on tests of the ‘response intention’ component of attention and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia: Part II. Semantic (category) fluency tasks and composite semantic and phonemic fluency measures	336
Table 48: Relationships between performance on tests of the ‘response initiation and inhibition’ component of attention (Stroop interference) and 2-, 3-, 5- and 11- dimensional models of symptoms in schizophrenia	342
Table 49: Summary of performance on neuropsychological tests	362
Table 50: Hypothesised groupings of neuropsychological tests according to the domains of attention identified by Cohen (1993)	365
Table 51: Obliquely-rotated Alpha Factor solution for the neuropsychological test items hypothesised to tap the domains of processing speed, attention span, and sustained performance	367
Table 52: Obliquely-rotated Alpha Factor solution for the neuropsychological test items hypothesised to tap the domains of selective attention, switching of attention, and response planning	372
Table 53: Three factor model using items from the SANS and SAPS. Symptom grouping based on Greube, Bilder and Goldman (1998) and Andreasen, Arndt, Alliger, Miller and Flaum (1995).	376
Table 54: Five factor model using items from the PANSS. Symptom grouping based on White, Harvey, Lindenmeyer and the PANSS Study Group (1997) and Lindenmeyer, Grochowski and Hyman (1995).	377
Table 55: Pearson’s Product-Moment Correlations between the three-dimensional model based on items from the SANS and SAPS and the individual items of the PANSS and BPRS-E.	380
Table 56: Three-factor symptom model, using items from the SANS, SAPS, PANSS, and BPRS-E consistent with the 11 dimension model	381
Table 57: Pearson’s Product-Moment Correlations between the five-dimensional model based on items from the PANSS and the individual items of the SANS and SAPS.	384
Table 58: Five-factor symptom model, using items from the SANS, SAPS, PANSS, and BPRS-E consistent with the 11 dimension model	385
Table 59: Pearson correlations between original scale-specific three- and five- dimension models of schizophrenia and the derived models using items from the SANS, SAPS, PANSS and BPRS-E for consistency with the eleven dimensional model	386
Table 60: Relationships between the adjusted three-factor model of symptomatology in schizophrenia and the eleven-factor model identified in the current study	388

Table 61: Relationships between the adjusted three- and five-factor model of symptomatology in schizophrenia and the eleven-factor model identified in the current study	389
Table 62: Pearson product-moment correlations between identified domains of attention and symptoms under the three-, five- and eleven- factor models	393
Table 63: Partial correlations between identified domains of attention and symptoms under the three-, five- and eleven- factor models. Partial correlations remove the variance explained by other symptoms within the given model	394
Table 64: Power calculations for significant correlations at $p=0.05$ (two tailed), at power = 0.8, raw Pearson correlations (above) used as the population estimate (alternative hypothesis); $r=0$ set as null hypothesis	395
Table 65: Summary of stepwise multiple regression analyses predicting performance on five domains of attention from symptom dimensions under the three-, five- and eleven- factor models of the symptomatology of schizophrenia	396
Table 66: Pearson correlations between symptom groupings identified as significant predictors of the combined 'processing speed' domain of attention and the individual tests comprising this combined score.....	398
Table 67: Pearson correlations between the individual symptoms comprising the 'cognitive dysfunction' symptom factor and the individual tests comprising the combined 'processing speed' score	402
Table 68: Pearson correlations between individual symptoms comprising those symptom groupings emerging as significant predictors of performance on the 'speed' composite score under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.....	405
Table 69: Pearson correlations between individual symptoms comprising those symptom groupings emerging as significant predictors of performance on the 'sustain' task under the three-, five- and eleven- factor models of the symptomatology of schizophrenia	412
Table 70: Pearson correlations between symptom groupings identified as significant predictors of the combined 'span' domain of attention and the individual tests comprising this combined score	414
Table 71: Pearson correlations between individual symptoms comprising those symptom groupings emerging as significant predictors of performance on the 'span' composite score under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.....	419
Table 72: Pearson correlations between symptom groupings identified as significant predictors of the combined 'flexibility' domain of attention and the individual tests comprising this combined score	424
Table 73: Pearson correlations between individual symptoms comprising those symptom groupings emerging as significant predictors of performance on the 'flexibility' composite score under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.....	430
Table 74: Summary of symptom grouping inter-relationships and correlations with attentional components.....	447
Table 75: Cognitive processes required for the successful completion of neuropsychological measures used in this study	457
Table 76: Comparison of clinical participants with an age-matched neurologically intact control group on measures of smooth pursuit eye movement performance.....	537
Table 77: Pearson product-moment correlations between single-mode pursuit eye tracking gain (tracking with all saccadic and eye-blink components removed) and symptoms under the three-, five- and eleven- factor models.....	549

Table 78: Partial correlations between single-mode pursuit eye tracking gain (tracking with all saccadic and eye-blink components removed) and symptoms under the three-, five- and eleven- dimension models. Partial correlations remove the variance explained by other symptoms within the given model.....	550
Table 79: Power calculations for significant correlations between single-mode pursuit eye tracking gain (tracking with all saccadic and eye-blink components removed) and symptoms under the three-, five- and eleven- factor models of the symptomatology of schizophrenia at $p=0.05$ (two tailed), at power = 0.8, raw Pearson correlations (above) used as the population estimate (alternative hypothesis); $r=0$ set as null hypothesis.....	551
Table 80: Summary of stepwise multiple regression analyses predicting single-mode pursuit eye tracking gain performance (tracking with all saccadic and eye-blink components removed) from symptom dimensions under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.	552
Table 81: Pearson product-moment correlations between the number of ‘positive’ forward-direction saccades during smooth linear pursuit eye tracking and symptoms under the three-, five- and eleven- factor models, as a function of target velocity	559
Table 82: Partial correlations between the number of ‘positive’ forward-direction saccades during smooth linear pursuit eye tracking and symptoms under the three-, five- and eleven- factor models, as a function of target velocity. Partial correlations remove the variance explained by other symptoms within the given model	560
Table 83: Power calculations for significant correlations between the number of ‘positive’ forward-direction saccades during smooth linear pursuit eye tracking and symptoms under the three-, five- and eleven- factor models at $p=0.05$ (two tailed), at power = 0.8, raw Pearson correlations (above) used as the population estimate (alternative hypothesis); $r=0$ set as null hypothesis	561
Table 84: Summary of stepwise multiple regression analyses predicting the number of ‘positive’ forward-direction saccades during smooth linear pursuit from symptom dimensions under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.....	562
Table 85: Pearson correlations between individual symptoms comprising those symptom domains emerging as significant predictors of the number of ‘positive’ forward-direction saccades during smooth linear pursuit from symptom dimensions under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.	563
Table 86: Pearson product-moment correlations between the number of backward-direction ‘reversal’ saccades during smooth linear pursuit eye tracking and symptoms under the three-, five- and eleven- factor models, as a function of target velocity.....	571
Table 87: Pearson product-moment correlations between the number of backward-direction ‘reversal’ saccades during smooth linear pursuit eye tracking and symptoms under the three-, five- and eleven- factor models, as a function of target velocity.....	572
Table 88: Power calculations for significant correlations between the number of backward-direction ‘reversal’ saccades during smooth linear pursuit eye tracking and symptoms under the three-, five- and eleven- factor models at $p=0.05$ (two tailed), at power = 0.8, raw Pearson correlations (above) used as the population estimate (alternative hypothesis); $r=0$ set as null hypothesis.....	573
Table 89: Summary of stepwise multiple regression analyses predicting the number of backward-direction ‘reversal’ saccades during smooth linear pursuit from symptom	

dimensions under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.....	574
Table 90: Pearson correlations between individual symptoms comprising those symptom domains emerging as significant predictors of the number of backward-direction ‘reversal’ saccades during smooth linear pursuit from symptom dimensions under the three-, five- and eleven- factor models of the symptomatology of schizophrenia	575
Table 91: Pearson correlations between individual symptoms comprising those symptom domains emerging as significant predictors of the number of backward-direction ‘reversal’ saccades during smooth linear pursuit from symptom dimensions under the three-, five- and eleven- factor models of the symptomatology of schizophrenia.	576
Table 92: Differences between clinical participants classed as having disordered eye tracking and normal eye tracking.....	580
Table 93: Summary of symptom grouping inter-relationships and correlations with measures of eye tracking.....	605
Table 94: Summary of evidence in support of the independence and external validity of the symptom groupings identified in the current thesis.....	636

List of Figures

Figure 1: Single disease process model of schizophrenia.....	25
Figure 2: Subtype model of schizophrenia: multiple, related, mutually exclusive, disease entities, each manifesting a range of symptomatology	25
Figure 3: Dimensional model of schizophrenia: multiple disease entities, each underlying a distinct group of symptoms. Entities are neither mutually exclusive nor necessarily solely restricted to schizophrenia.....	25
Figure 4: Schematised ‘pyramidal model’ of schizophrenia of Kay and Sevy (1990).....	80
Figure 5: Complete linkage (furthest neighbour) hierarchical cluster analysis with Pearson correlation as a distance measure for the included 57 clinical items of the PANSS, SANS, SAPS and BPRS-E.....	158
Figure 7 Sorted correlation matrix of the 57 clinical items from the SAPS, SANS, PANSS and BPRS-E from 100 individuals with a diagnosis of schizophrenia or schizoaffective disorder.....	164
Figure 8: Distribution of items contributing to the ‘hostility’ symptom grouping.....	170
Figure 9: Distribution of items contributing to the ‘conceptual disorganisation’ symptom grouping.....	170
Figure 10: Distribution of items contributing to the ‘excitement’ symptom grouping ..	170
Figure 11: Distribution of items contributing to the ‘grandiosity’ symptom grouping.	170
Figure 12: Distribution of items contributing to the ‘loss of boundary delusions’ symptom grouping.....	182
Figure 13: Distribution of items contributing to the ‘somatization’ symptom grouping	182
Figure 14: Distribution of items contributing to the ‘auditory hallucinations’ symptom grouping.....	182
Figure 15: Distribution of items contributing to the ‘paranoia’ symptom grouping	182
Figure 16: Distribution of items contributing to the ‘anxious intropunitiveness’ symptom grouping.....	194
Figure 17: Distribution of items contributing to the ‘cognitive dysfunctions’ symptom grouping.....	194
Figure 18: Distribution of items contributing to the ‘negative signs’ symptom grouping	194
Figure 19: Distribution of items contributing to the ‘social dysfunctions’ symptom grouping.....	194
Figure 20: Sorted correlation matrix of clinical items from the SAPS, SANS, PANSS and BPRS-E from 100 individuals with a diagnosis of schizophrenia or schizoaffective disorder, following the item reliability analysis process.....	216
Figure 21: Sorted correlation matrix of clinical items from the SAPS, SANS, PANSS and BPRS-E from 100 individuals with a diagnosis of schizophrenia or schizoaffective disorder, following the item reliability analysis process. Only the dimensions deemed reliable are included.	217
Figure 22: Correlations between symptom dimensions proposed in the current study, arranged in comparison with the three and five factor models of schizophrenia. .	222
Figure 24: Possible mediating factors in the relationship between neurocognition and functional outcome (from Green & Nuechterlein, 1999).....	471
Figure 25: Smooth pursuit eye movement recording to an 0.4 Hz sinusoidal target stimulus traversing 20° of visual angle for an observer with a diagnosis of schizophrenia, a first-degree relative of a schizophrenia patient, and a neurologically-intact control participant	480
Figure 26: Schematic examples of four types of saccadic intrusions during eye tracking	487

Figure 27: Schematic summary diagram of the neural circuitry involved in human and primate smooth pursuit eye movement control	498
Figure 28: Locations of cortical areas involved in the control of eye movements.....	498
Figure 29: Examples of smooth and jumping dot pursuit eye movement in two randomly selected observers with schizophrenia and one randomly selected neurologically-intact observer.	536
Figure 30: Dual-mode pursuit eye velocity as a function of target velocity (removing any eye blink periods). Error bars represent ± 1 standard deviation.	538
Figure 31: Single-mode pursuit eye velocity as a function of target velocity (removing any eye blink or saccadic periods). Error bars represent ± 1 standard deviation.	539
Figure 32: Mean number of positive-direction saccades as a function of target velocity. Error bars represent ± 1 standard deviation.....	540
Figure 33: Mean number of backward-direction ‘reversal’ saccades as a function of target velocity. Error bars represent ± 1 standard deviation.	541